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U.S. PATENT APPLICATION

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Invention: METHODS AND SYSTEMS FOR THE CONTINUOUS IN-LINE COATING AND FABRICATION OF HOOP STEEL REBAR FOR CONCRETE STRUCTURES

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SPECIFICATION

METHODS AND SYSTEMS FOR THE CONTINUOUS IN-LINE COATING AND FABRICATION OF SPIRALED STEEL REBAR FOR CONCRETE STRUCTURES

FIELD OF THE INVENTION

The present invention generally relates to methods and systems for the continuous in-line coating of bent concrete rebar products, known as "spirals" or "spiraled steel".

BACKGROUND AND SUMMARY OF THE INVENTION

It is notoriously well known to employ steel or other metal reinforcing rods or bars known colloquially as "rebar" to reinforce structural members formed of cementitious materials, such as concrete, so as to improve the concrete structure's tensile strength. Although steel and other metal rebar can in fact enhance the tensile strength of the concrete structure, they are susceptible to oxidation. For example, ferrous metal rusts by the oxidation thereof to the corresponding oxides and hydroxides or iron by atmospheric oxygen in the presence of water.

Steel rebar within a concrete structure remains passive provided that the concrete remains highly alkaline. That is, since concrete is typically poured at a pH of 12 to 14 (i.e., at high alkalinity) due to the presence of hydroxides of sodium, potassium and calcium formed during the hydration of the concrete, oxidation of the steel rebar is typically not a concern in the short term. However, over time, exposure to a strong acid (such as typically occurs by virtue of chlorine ions from road salt, salt air in marine environments and/or salt-contaminated aggregate (e.g., sand) used to make the concrete) lowers the initial pH of the concrete thereby

allowing the steel rebar therein to corrode, for example, by means of an electrolysis effect. When the rebar corrodes, it can expand and create internal stresses in the concrete which ultimately are revealed by cracking and, ultimately disintegration, of the concrete.

It has therefore been conventional practice to coat the rebar with a thermoset epoxy resin coating in order to minimize the rebar's susceptibility to corrosion. The epoxy coating of rebar is not, however, without problems. For example, the epoxy coating on the rebar is highly susceptible to cracking during bending of the rebar to form so-called spiral steel rebar (that is, rebar bent into a generally round or rectangular cross-sectional "hoop" that is tied to vertical linear rebar in concrete columns).

Specifically, cracking of the epoxy coating can and does occur during bending if there exists a less than optimum state of cleanliness of the rebar resulting in an insufficient anchor profile patter of the surface of the bar to hold the coating, or if the coating thickness is uneven (i.e., to thin or too thick from optimum thickness. For these reasons, the spiral steel rebar is typically first formed into the desired geometric hoop configuration, and then subjected to a powder-coating operation whereby a shot blasting process (i.e., to create a roughened surface, or anchor profile on the steel) precedes a thermoset epoxy resin powder coating operation onto the anchor-profiled rebar surfaces.

Such batch coating of pre-formed spiraled steel however is problematic in that uneven blasting and/or coating thickness of the rebar along its interior typically ensues thereby leading to premature corrosion problems in use. That is, the nature of a reinforcing bar pre-formed into a spiral configuration of virtually any dimension causes problems during preparation and coating on the interior of the spiral shaped material. For

example, the distance of the interior portions of the spiral shaped rebar material from both the blast heads and/or powder coating apparatus, as well as the inevitable masking of the interior portions of the spiral by the exterior portions thereof, typically contribute to unsatisfactory and/or uneven coatings. Thus, the epoxy coating thickness on the interior of the spiraled steel tends to be less than the exterior due to masking effects during the powder coating operation.

It would therefore be highly desirable if methods and systems were provided to allow spiraled steel rebar to be reliably and evenly epoxy-coated. It is towards fulfilling such a need that the present invention is directed.

Broadly, therefore, the present invention is embodied in methods and systems for the continuous coating and fabrication of spiraled steel rebar product for concrete structures. In especially preferred forms, the present invention includes methods and systems by which linear uncoated rebar is supplied to a polymeric (preferably, epoxy) powder-coating unit whereby a substantially uniform coating layer of a polymeric material is applied onto the uncoated rebar to form a linear coated rebar; and thereafter the linear coated rebar is bent into a spiraled steel rebar product. The spiraled steel rebar product of this invention could be fabricated in virtually any desired size. Thus, for example, the spiraled steel rebar product of the present invention may be in the form of a continuous steel rebar having between about 40 to about 50 spiral turns and weighing up to about 4000 pounds.

The bending unit employed to bend the linear coated rebar is provided with a series of bending wheels comprised of separated upstream and downstream bending wheels and a central bending wheel

which is disposed between and below these upstream and downstream bending wheels. By bringing the linear coated rebar into contact with the series of bending wheels, the rebar may be bent gently into spiraled steel rebar product without damage to the polymeric surface coating. In this regard, it has been found that such gentle bending of the coated rebar may be advantageously accomplished using bending wheels which include a synthetic or natural rubber tire mounted on a rigid rotatable wheel member.

These and other aspects and advantages of the present invention will become more clear after careful consideration is given to the following detailed description of the preferred exemplary embodiments thereof which follow.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

Reference will hereinafter be made to the accompanying drawings wherein like reference numerals throughout the various FIGURES denote like structural elements, and wherein,

FIGURE 1 is a schematic side elevational view showing a particularly preferred system for the continuos epoxy-coating of spiraled steel rebar; and

FIGURE 2 is an enlarged perspective view of the rebar spiraled bending unit in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Accompanying FIGURE 1 schematically depicts one presently preferred system 10 for continuously coating steel rebar with a

thermosetting epoxy powder and forming the coated rebar into spiraled steel. Specifically, as shown therein, the uncoated rebar 12a is typically provided in a coil 12. By way of example only, the rebar may be #5 5/8-inch diameter rebar. Virtually any other size of rebar, however, may be coated satisfactorily according to the present invention. The rebar 12a is uncoiled from the supply coil 12 and fed to a bar straightener 14 provided with a series of rollers 14a which serve to remove coil-shape memory from the rebar 12a so that it can be processed linearly through the downstream unit operations.

It will be appreciated of course that throughout this specification, reference will be made to "bar" when referencing the steel stock which is employed in the practice of the present invention. It should therefore be understood that such a term is being used in its art-recognized sense to mean generically any elongate steel member of any desired cross-sectional configuration that may be employed as a reinforcement member for cement structures. Thus, the term "bar" encompasses round cross-sectional wire or rods and well as rectangular cross-sectional bars.

A cleaning unit 16 is provided immediately downstream of the bar straightener 14. The cleaning device 16 is most preferably a "dry" cleaner in that it uses rotating vaned wheels which throw an abrasive (e.g., hardened steel grit) at the bar 12a. The abrasive force of the grit thereby removes debris and/or surface oxidation from the uncoated rebar 12a. In addition, the surface of the rebar is abraded sufficiently by the grit to provide a specified anchor profile to improve the mechanical adherence of the later applied epoxy coating.

The cleaned rebar 12a is then directed to a heating unit 18. Most preferably, the heating unit 18 is an induction heating coil which serves to

heat the uncoated steel rebar 12a to an elevated temperature of about 475^{0}F as it passes therethrough. The rebar 12a thus enters the powder-coating unit 20 at an elevated temperature sufficient to fusion bond the applied epoxy powder. In this regard, the coating unit 20 most preferably applies the epoxy powder electrostatically onto the heated steel rebar 12a using electrostatic spray guns in a manner well known to those in this art. The electrostatically applied epoxy powder will thus coat the exterior surface of the rebar 12a and will fuse so as to form a uniform layer of epoxy resin on all of the rebar's surfaces.

The epoxy-coated rebar (now identified as reference numeral 12b) exits the powder-coating unit 20 and is directed to a quench chamber 22. In this regard, it is important for the epoxy coating layer to cure prior to being subjected to the water spray within the quench chamber 22. Thus, the distance between coating unit 20 and the quench chamber 22 must be sufficient at the linear run rate of the coated rebar 12b to allow for sufficient curing to ensue. Most preferably, the epoxy coating on the coated rebar 12b is allowed to cure for about 30 seconds prior to entering the quench chamber 22. As briefly noted above, the quench chamber 22 sprays water onto the surface of the epoxy-coated rebar so as to cool it to a sufficiently low temperature which would allow manual worker handling of the coated rebar without injury.

The cooled and epoxy-coated rebar 12b is passed through the nip of an opposed set of wet sponges 24a, 24b which are charged with a low voltage for an electrical potential generating unit 24c. Should a hole (colloquially known in this art as a "holiday") or defect occurs in the coating, an electrical circuit is completed through the rebar which is detected by the alarm unit 24d which causes an audible and/or visual alarm to be generated that may be recorded by the defect recorder unit

24e. As a result, the number of defects of the entirety of the spiraled coated rebar product may be determined.

The spiral forming unit 26 serves to bend the linear epoxy-coated rebar 12b into a non-linear curved hoop so as to form a continuous spiraled steel product 30 as is perhaps better shown in accompanying FIGURE 2. Specifically, the spiral forming unit 26 is provided with a central bending wheel 32 which is disposed between, but vertically lower than upstream and downstream bending wheels 34, 36, respectively. Most preferably each of the bending wheels 32, 34 and 36 is a rubber-like (e.g., synthetic rubber) tire 32a, 34a and 36a mounted on a rigid inner wheel 32b, 34b and 36b. A guide roll assembly 38 is provided so as to guide the advancing coated rebar 12b into the bending unit 26.

A support spool 40 for supporting the spiraled steel 30 during its formation is connected to and extends coaxially outwardly from the central bending wheel 32 in a cantilevered manner. The support spool 40 is provided with a flange member 40a at its free terminal end so as to prevent the spiraled steel from slipping off the spool 40.

As may be better depicted in accompanying FIGURE 1, the coated rebar 12b is introduced into the bending unit 26 in an orientation that is substantially tangential to both the upstream and central bending wheels 32, 34, respectively. It will be noted in this regard, that the upstream bending wheel 34 is vertically offset from (i.e., higher than) both the central bending wheel 32 and the downstream bending wheel 36. This amount of vertical off-set and the horizontal spacing between the upstream and downstream bending wheels will therefore determine the radius of curvature imparted to the incoming rebar 12b, and hence the diametrical size of the spiraled steel 30. It will, of course, be understood

that relative adjustment of the positional relationships between these bending wheels 32, 34 and/or 36 as well as providing additional bending wheels will allow the fabricator to form spiraled steel products of different diameters and/or geometric configurations. Thus, for example, the bending unit 26 may be modified by adding additional bending wheels similar to those described above so as to form generally rectangular spiraled steel products.

The pliant nature of the tires 32a, 34a and 36a allows the incoming linear coated rebar 12b to be gently bent into a spiraled steel product without damage to the epoxy coating thereon. Thus, in accordance with the present invention, a spiraled steel product may be fabricated having a uniform epoxy coating layer on all sides of the rebar's circumference and along the rebar's entire length. This, in turn, results in spiraled steel having greater resistance to corrosion in the field and thereby improved structural reliability.

Therefore, while the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.